

# Malaria Eradication in the United States\*

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IN 1945 the Public Health Service and the southeastern states undertook a cooperative program of malaria control in civilian areas. This was a logical extension of the activities conducted around areas of military importance during the preceding five years. The philosophy of the extended program was as follows:

1. Malaria was recognized as a gradually declining disease in the United States,<sup>1</sup> but was still believed to be present in many regions of the 13 traditionally malarious states of the Southeast. The morbidity and mortality reports at that time indicated many thousands of cases. Based on previous experience, it was the common belief that such reports, at least of morbidity, underestimated the total incidence of infection. While the trends of morbidity and mortality were steadily downward, it was felt that a well coordinated, large-scale control program might eliminate the disease entirely.

2. Many malariologists over the years believed that malaria occurred in cyclical form,<sup>2, 3</sup> though no convincing explanation of the basis for such a pattern in this country was ever advanced. The 1936 epidemic in the United States accompanied and seemed to be related to the depression, an association which has been noted previously in this and other countries.<sup>4, 5</sup> A resurgence of malaria with a post-war depression was a possibility which gave malariologists and health officials serious concern.<sup>6-9</sup> If malaria could be knocked out completely before such a depression ensued, this disease could not be present to augment the

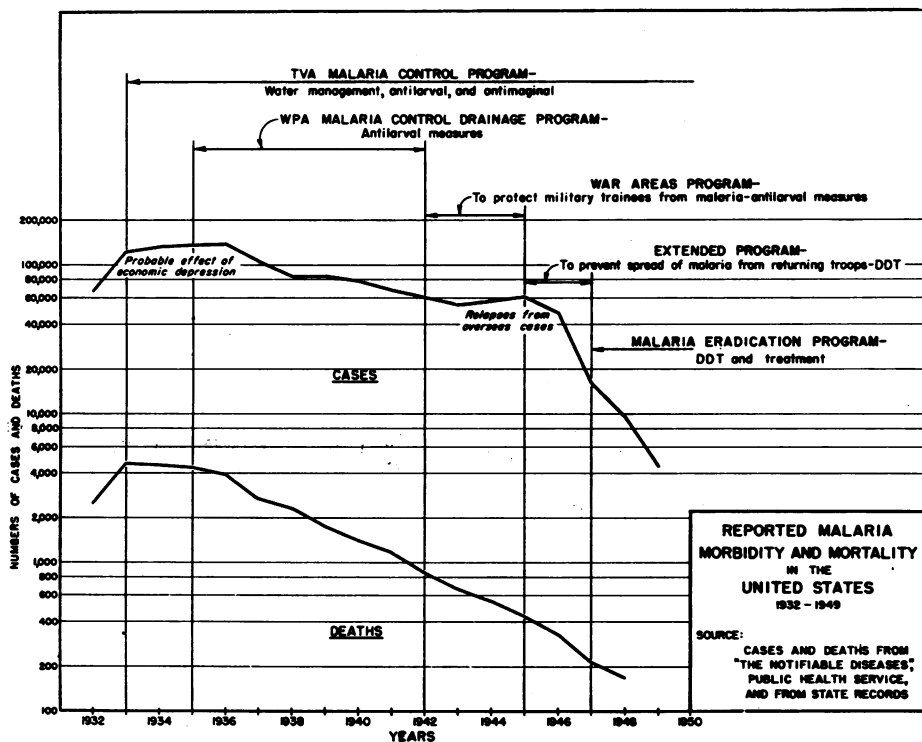
misery and poverty of the affected population. 3. During 1945 and 1946 many thousands of veterans returned from overseas theaters, particularly the South Pacific, carrying peculiarly relapsing types of *Plasmodium vivax* infection. It was shown experimentally that these strains could be transmitted effectively by our native anopheline species.<sup>10</sup> It was feared that they might become established in this country, especially in the Southeast where anophelism still prevailed.

4. Purposeful malaria control, cooperatively undertaken by state, local, and federal agencies appeared to have already aborted the "cyclicality" of the disease. If more of the same effective teamwork could prevent the establishment of imported malaria, the project would be vastly worth while to the nation.

The basic operation of the proposed program represented a complete change from previous malaria control activities. Larviciding, drainage, and programs to promote insect-proofing of houses were abandoned and efforts were concentrated upon the use of indoor residual DDT sprays in areas where endemic malaria was known to be present or had been recently reported.<sup>11</sup> The principle of this new program was very simple. Instead of trying to reduce the general abundance of anopheline mosquitoes, lethal measures were aimed specifically at the small proportion of anophelines that actually bite man. If these could be killed before they had the opportunity to bite human beings a second time, malaria could not be transmitted. The success of this procedure had already

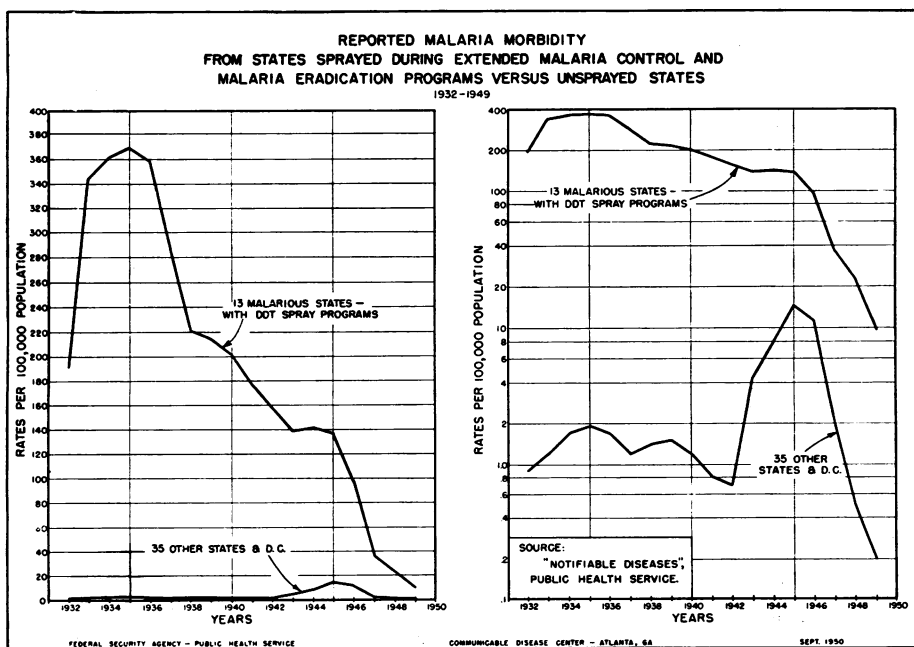
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FIGURE 1



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FIGURE 2



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been well demonstrated in various parts of the world.<sup>12, 13</sup>

Accordingly, in 1945, this program was initiated in selected civilian areas and, by 1947, a comprehensive project was under way throughout the Southeast with the stated objective of eradicating malaria as an endemic disease within five years. The end of this period (June 30, 1952) is drawing near. It is appropriate, therefore, to make a critical evaluation of the progress to date.

In 1945, a total of 62,763 cases of malaria was reported in the United States; 78 per cent of these occurred in the 13 "traditionally malarious" states. In 1949, a total of 4,241 was reported. This constitutes an apparent reduction of 91 per cent in the five years of the residual spray control program. This figure, however, has scant significance because it was found in the process of making the studies here reported that the malaria morbidity statistics during this period were grossly misleading. Evidence to support this statement will be presented.

In attempting to evaluate the present status of malaria incidence, reliance has been placed primarily on the discovery and investigation of laboratory-confirmed parasitism. This may be considered an excessively exclusive criterion of infection. Nevertheless, it is the most objective test available, if affirmed by competent microscopists. In laboratories where induced mosquito-borne malaria is being studied, it is the usual experience to find parasites in patients as long as they manifest symptoms of vivax or quartan infection; indeed, the period of detectable parasitemia usually exceeds that of illness.<sup>14, 15</sup> Non-detected parasitemias during the clinical exhibition of falciparum malaria are a trifle more frequent, but even here the correlation between parasites and symptoms is high. Unfortunately, adequate parasitologic data pertaining to reported malaria are not available over the years, but in 1949

a beginning was made in the systematic collection of the available facts. A critical review of them leads to the conclusion either that malaria has already been substantially eradicated as an endemic problem or that the data are grossly insufficient.

The information to be presented in support of these statements is of three types.

1. The malaria morbidity and mortality statistics of the United States since 1932.
2. An analysis of the laboratory examinations for malaria parasites made during the last 18 years in the laboratories of state health departments, the Tennessee Valley Authority, and the Public Health Service.
3. The results of the malaria appraisal activities undertaken by the Communicable Disease Center together with the states participating in the eradication program.

#### REPORTED MALARIA MORTALITY AND MORBIDITY

The numbers of cases and deaths attributed to malaria in the nation are shown by years in Figure 1. The mortality statistics will not be analyzed in detail because these have been known for many years to be patently inaccurate.<sup>16-18</sup> Malaria in this country is rarely a malignant disease and during the last decade almost never a primary cause of death. The mortality curve slopes steadily downward, but the numbers of deaths are spuriously high and their trend should incline more sharply.

Malaria morbidity statistics are also grossly erroneous, but because of their temporal association with events which may have been related to changes in trend, more consideration has been given to their interpretation (Figure 1). Figure 2 shows the annual incidence of reported malaria cases in the 13 states which have participated in the malaria eradication program\* and in the rest of the United States from 1932 to 1949.

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\* Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas.

This period may be divided into four arbitrary sections.

1. During the first, from 1932 to about 1940, malaria was epidemic in much of the South. This is shown by the 1933-1936 peak on the graphs. In surveys of malarious areas it was the usual experience to find many infected individuals. Parasite rates up to 50 per cent were not uncommon in children,<sup>19, 20</sup> though the numbers of cases reported were only a small fraction of those indicated by these levels of parasitism. The statistics of this period were characterized, therefore, by under-reporting. However, during the next decade this situation changed drastically so that now it is equally possible to prove—as shown below—that the number of reported cases grossly exceeds the number of true infections.

2. The second period of interest in Figure 2 is the progressive decline of malaria morbidity between 1938 and 1943. Laboratory evidence shown below indicates that the decline was more rapid than the morbidity curve suggests.

3. The third section of Figure 2 is the period from 1943 through 1947 when there is a slight bulge in the malaria incidence curve for the eradication states and a marked peak in the reported incidence for the rest of the nation. This clearly represents the importation of malaria by troops returning from overseas and relapsing in this country. Some idea of the extent to which infection was thus introduced is apparent from these charts, but it must be recognized that, even in the states where reporting is excellent, the number of cases recorded probably represents only a small fraction of the total which occurred.

4. The fourth period of interest is that since 1947 when there appears to have been an accelerated decline in reported cases in the 13 states. One would be tempted to interpret this extraordinary descent as the logical consequence of

effective malaria control, but the fact is that it can be explained on a purely statistical basis. It is due primarily to a change in the method of morbidity reporting by the State of Mississippi in 1947, requiring the identification of patients. The result of this change was that while 17,764 cases were reported in Mississippi in 1946, only 914 were notified in 1947. A similar change in reporting procedure was instituted in South Carolina in 1949. At the present time, Texas is the only remaining state whose morbidity reporting system does not identify the patient. It is believed that these transitions plus the elimination by states of obviously doubtful reports based on appraisal are responsible for the abrupt decline in reported malaria morbidity since 1947.

#### BLOOD EXAMINATIONS FOR MALARIA PARASITES

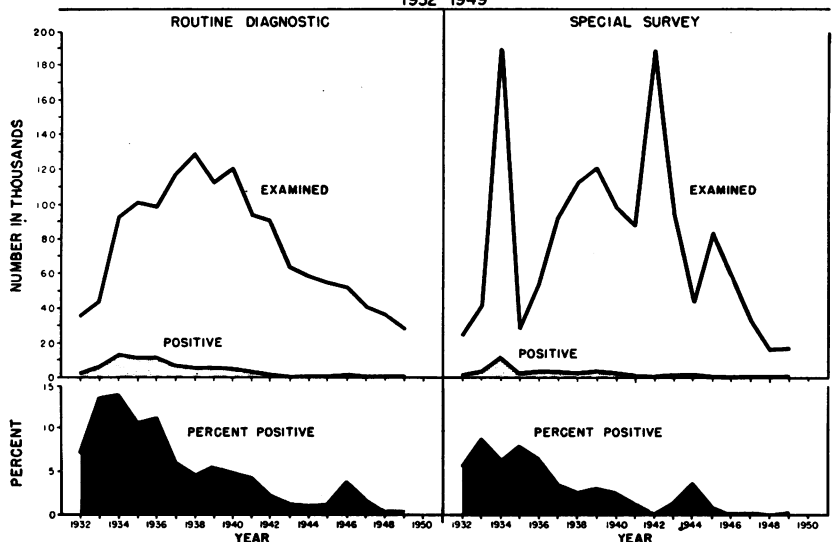
The laboratory examinations for malaria are considerably more revealing. They comprise two groups, routine diagnostic examinations requested by physicians and special surveys made to measure the endemicity of malaria. The numbers of smears \* and the percentages positive are shown by years since 1932 in Figure 3. The quantities of diagnostic and of survey slides examined each year are considerable. The most important indication from these data is the generally diminishing trends of the percentages of slides positive. The 1946 peak of the diagnostic curve resulted from relapses during and after the repatriation phase of the war. The 1944 peak in the survey curve represents the effect of the latest local epidemic in the nation, experienced near the Santee-Cooper impoundment in South Carolina.

It is also significant that the numbers of the diagnostic slides have decreased markedly and continuously since 1939,

\* Our thanks to the directors and staffs of the laboratories who assisted in locating and interpreting the records of malaria examinations—a musty job!

FIGURE 3

BLOOD EXAMINATIONS FOR MALARIA PARASITES MADE IN THE 13 ERADICATION STATES  
BY STATE AND FEDERAL LABORATORIES  
1932-1949



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implying that fewer and fewer patients were suspected of having malaria. The two spikes appearing in the curve of survey slides examined record the results of two surveys made throughout the South. It is interesting to note that the percentage positive of the first (1934) was 6.1, of the second (1942) 0.3.

It is evident from Figure 3 that, since 1942, blood surveys have been more useful in determining the virtual absence of malaria than in measuring its endemicity.

#### MALARIA APPRAISAL PROGRAM

In 1947, the Communicable Disease Center initiated a program of malaria appraisal to evaluate progress toward the eradication of the disease. Medical and nurse epidemiologists were assigned to states to appraise individual cases and deaths attributed to malaria, to investigate reported outbreaks of the disease, and to promote better diagnosis and treatment.

During the first two years of this program, the numbers of reported cases were so large that complete coverage of individual case reports was out of the question. Activities, therefore, were directed to visiting the few physicians whose reports accounted for the majority of the cases and deaths in the state. Efforts were made to confirm these but they were rarely successful.

Beginning in 1949, however, greater stress was laid upon individual case appraisal as the primary responsibility in the program. In this year, therefore, there is a beginning of reasonably adequate data on individual cases. Public Health Service personnel were assigned continuously in the States of Mississippi and South Carolina and for part of the year in the States of Georgia, Alabama, Arkansas, and Texas. As many as possible of the reported cases and deaths from malaria were investigated, obtaining all pertinent facts of epidemiologic significance. Of particular importance

were the history of malaria attacks, of trips out of the country to malarious areas, of recent transfusion, and of anti-malarial treatment. These records were reviewed by state epidemiologists who appraised them as to confirmation and source of infection.

During this year a total of 55 positive cases were confirmed in 8 of the 13 traditionally malarious states. As shown in Table 1, these were the yield of 494 appraisals made in 7 states. Of these, 19 were not wholly and adequately explained as being relapses, transfusions, or clearly imported cases. These 19 which have been classified as indigenous primary malarias have certain unusual characteristics, namely that each has occurred sporadically and without clear relation to another case. Many have occurred under epidemiologic circumstances which raise serious question that they could be indigenous or primary, but they have still been so classified for want of other explanation. Reliable instances of primary cases are so few and far between that the occurrence of consecutive transmission is debatable. The question can be resolved only by more

critical diagnosis, reporting, and investigation.

#### CONCLUSIONS

1. Since the 1933-1937 epidemic, the numbers of reported malaria deaths have maintained a regular trend downward in the nation and in the 13 states participating in the National Malaria Eradication Program.

2. During the same period, reported malaria morbidity has diminished steadily in the nation and in the eradication states except for the temporary increases due to the demobilization of service personnel. The other states experienced a proportionately higher wave of relapses at the same time but this has now subsided.

3. Evidence from the field investigation and appraisal of alleged malaria deaths and cases indicates that more of these are now being reported than can be verified, that the rates of decline of malaria mortality and morbidity are actually steeper than official reports indicate, and that both of these attributes are currently closer to zero than is commonly supposed.

4. Critical case appraisal of reported malaria morbidity in 7 states revealed the presence of 19 instances which could not be explained on some basis other than transmission in this country.

5. A careful review of reported malaria mortality and morbidity, of diagnostic and survey blood examinations, and of case appraisals, all support the contention that en-

TABLE 1

*Appraisal\* of Malaria Cases Reported or Known to Have Occurred in 1949*

State	Reported in 1949	Cases Appraised	Total	Parasite-positive in state approved laboratory					
				Indigenous		Intro- duced	Trans- fusion	Induced	Source Unknown
				Primary	Relapse				
Alabama	134	27	3		1	2			
Arkansas	323	116	2	1			1		
Florida	43								
Georgia	91	89	19		2	14			3
Kentucky	21								
Louisiana	21	1	1	1					
Mississippi	72	96	4	3		1			
Missouri	4								
North Carolina	53	2	2	1	1				
Oklahoma	92								
South Carolina	242	153	18	9	4	1	1	1	2
Tennessee	35	2	0						
Texas	2,881	8	6	4		2			
Total	4,012	494	55	19	8	20	2	1	5
Other States and D. C.	229	4	0						

\* Through July 31, 1950. The contributions of state and federal epidemiologists are acknowledged.

demic malaria has been reduced to the vanishing point. But these data are not considered sufficiently extensive to prove that malaria has been eradicated from this country.

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## NSPB News

The National Society for the Prevention of Blindness has initiated its program for developing state and local societies by affiliating three local societies, the Detroit and Washington, D. C. Societies and the Pittsburgh Branch of the Pennsylvania Association for the Blind.

The Wise Owl Club, sponsored by the National Society, is made up of workers who by proper safety measures saved their eyesight in an accident that would otherwise have blinded them. The

1,000th Membership Certificate was recently awarded to Clayre Pomeroy of the Reynolds Metal Company in Phoenix, Ariz. His safety goggles protected him when a chip flew off a carboloy bit. The presentation was made in Washington, D. C., by Secretary of Labor, Maurice T. Tobin.

NSPB has added two new vice presidents to its list of officers:

William L. Benedict, M.D., Mayo Clinic  
Ira V. Hiscock, D.Sc., chairman, Department of Public Health, Yale University